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XII.—*Investigations upon the Structure and Natural History of the Vorticellæ.* By Dr. RICHARD GREEF*.

[Plates XII.—XVI.]

THE *Vorticellæ* are among those Infusoria which were earliest and have been most frequently examined. From Leeuwenhoek, who first observed them and with them the first Infusorial forms, down to the most recent times, most naturalists seem to have turned with particular preference to this elegant group of animals. Leaving out of consideration that many were probably induced, by the exceedingly attractive phenomena of form and existence presented by the bell-animalcules, to a closer examination of them, there is perhaps no Infusorial family which can be observed with more ease and certainty. In all waters, whether stagnant or flowing, fresh or salt, *Vorticellæ* occur, often appearing in great quantities by the extension of their colonies. Almost all are attached to stems, and therefore are on the whole better adapted for examination (although with occasional interruptions, as in the contractile-stalked forms) than most other Infusoria, which pass restlessly to and fro in the field of vision, and can often only be brought to the desired state of quietness by a pressure which more or less alters the normal conditions of form and life.

It is no wonder, then, that, with regard to these animalcules, many interesting facts of extreme importance to the knowledge of the lower animal world were early ascertained (such, for example, as the process of division and the formation of bud-like structures), and that, with the advancing diffusion and improvement of the microscope, and the lively interest that was directed towards the Infusorial world, the field of observed phenomena has become a very extensive one.

* Translated by W. S. Dallas, F.L.S., from the 'Archiv für Naturgeschichte,' Jahrg. xxvi. p. 353.

But notwithstanding all the labour that has been bestowed both upon the bell-animalcules and upon the Infusoria in general, notwithstanding numerous interesting individual observations, and especially notwithstanding the great abundance of systematic materials, it appears that we are still far from having even a moderately satisfactory insight into the organization and vital history of the Infusoria—nay, that in many respects we have perhaps made only the first still uncertain steps in the knowledge of this remarkably multifarious class of animals, in whose varied company we have to seek many forms more or less allied to or constituting the parent forms of other groups of animals, especially the Vermes and perhaps the Coelenterata, and which, by their universal distribution and their constantly recurring forms (in other words, by their truly cosmopolitan character), possess a special interest precisely in the above-indicated direction of their relationships to other animals.

The material for the present observations was furnished, as regards the freshwater forms, by the rich Infusorial fauna of the Schlossweiher of Poppelsdorf and some other stagnant waters in the environs of Bonn. Although I have submitted many of the genera and species occurring here to careful investigation, in these communications some forms to which I am indebted for the most abundant and important results are brought prominently forward, especially a species of *Epistylis*, which nearly approaches Ehrenberg's *Epistylis flavicans*. I say "nearly approaches," as I greatly doubt whether all the forms here noticed by me under this name belong to a single species, or, rather, whether we have not before us several different species or, at least, varieties, as, indeed, a glance at the appended figures (Pls. XV. & XVI.) may show. Not only do differences of size, colouring, and even, although in a less degree, of habitus occur, but also in the possession of apparently essential parts (that is to say, of organs), *e. g.* the peculiar shining capsules, hereafter to be described, which are furnished with a filament capable of being shot forth, and which display a close agreement with the netting-capsules of the Coelenterata (Pl. XV. fig. 5, *k*). In the course of our communications we shall again revert to the distinctness or identity of these forms.

The marine species which I have had the opportunity of examining are all from the North Sea at Ostend, where the occurrence of abundant material was always certain, especially in the oyster-parks there. These marine forms are represented on Plates XII. & XIII. (with the exception of fig. 8 on Pl. XIII.), in which the act of division and the gemmiform

conjugation are shown in detail, and the remarkable tuft of *Zoothamnium* in Pl. XIV. figs. 6 & 7.

Systematic Limitation of the Family Vorticellina.

Ehrenberg first founded the family Vorticellina nearly in accordance with our present conception of it, and with 8 genera and 38 species*. The systematic characters are so happily seized, that the family has recently been accepted by Stein essentially with the limitation given to it by Ehrenberg. Ehrenberg characterized the Vorticellina "as (polygastric) animalcules which possess an alimentary canal uniting the stomachs, have the mouth and efferent orifice separate but placed together in the same pit, and therefore are without a hinder part, which bear no carapace, and either move freely individually, or are attached, and often, by imperfect self-division, acquire a minute frutescent or arborescent form." The eight genera united in this family were:—*Stentor*, *Trichodina*, *Urocentrum*, *Vorticella*, *Carchesium*, *Epistylis*, *Opercularia*, and *Zoothamnium*. Stein †, and after him Claparède and Lachmann ‡, first of all, on account of the different organization in many respects, rightly separated from these the genus of the Stentors§, now generally placed with the Bursariæ, as they are ciliated over the whole body, whilst the true body of the *Vorticellæ* is naked and only bears a so-called adoral circle of cilia; moreover the anus of the Stentors, as Lachmann demonstrated, is different in position from that of the *Vorticellæ* &c. Then Claparède and Lachmann further separated the genus *Urocentrum* || (without sufficient foundation or investigation, indeed) from the Ehrenbergian system, forming with it a peculiar family, and united Ehrenberg's

* A very full and admirable summary of the older literature, with indications of the earlier conceptions as to the structure and systematic position of the Vorticellina, is given by Ehrenberg in his great work, 'Die Infusionsthierchen als vollkommene Organismen,' pp. 260, 269, 275, 279, 286, &c. At p. 275 especially there is a very valuable critical revision of the older system of *Vorticellæ* and of the synonyms of the individual species. We learn from it that the genus *Vorticella* alone displayed no fewer than 120 specific names, which were reduced by Ehrenberg to 9 for actual, distinct and well-characterized species.

† Die Infusionsthierchen auf ihre Entwicklungsgeschichte untersucht, p. 94.

‡ Etudes sur les Infusoires &c. i. p. 77.

§ Recently, as is well known, the Stentorinæ, as, indeed, was previously proposed by Lachmann (Müller's Archiv, 1856, p. 361 & p. 364, note 1), have been raised by Stein (Der Organismus der Infusionsthierchen, ii. p. 170) to the rank of a distinct family, with the genera *Stentor* and *Freia*, and placed in the order of the *Infusoria Heterotricha*.

|| Etudes &c. i. pp. 78 & 134.

genus *Opercularia* with *Epistylis*, so that of the eight original genera of Ehrenberg's Vorticellan family three were eliminated, namely *Stentor*, *Urocentrum*, and *Opercularia*.

On the other hand, however, Claparède and Lachmann, following Stein's example, included the *Ophrydina* (which Ehrenberg had placed, as *carapaced bell-animals*, in a separate family) in the Vorticellan family, side by side with the true naked Vorticellina, taking into consideration, certainly with justice, the in other respects similar habit and organization of the carapaced and naked forms, and regarded the gelatinous envelope of the *Ophrydina* as morphologically equivalent to the gelatinous stem of the *Vorticella*, which is secreted by similar processes, and especially to the rigid stem of *Epistylis*. From Ehrenberg's *Ophrydina*, which included the genera *Ophrydium*, *Tintinnus*, *Vaginicola*, and *Cothurnia*, before incorporating them with the Vorticellina, they separated *Tintinnus*, on account of the essential differences in its ciliation and organization; so that, by this addition of three genera, the original number of the members of the family was reestablished. But, besides this, three new genera were added, namely *Lagenophrys* in the place of *Tintinnus*, as a carapaced *Vorticella*, and the two naked forms, *Scyphidia* and *Gerda*—the first established by Stein*, the second by Dujardin but first accurately characterized by Lachmann†, and the third discovered by Lachmann and Claparède‡.

With all these additions and deductions, therefore, the Ehrenbergian family of the Vorticellina had grown to eleven genera, with a very considerable number of species. As the characters of this family, those previously established by Ehrenberg, (with the exception of the polygastric nutritive apparatus, which Ehrenberg had assumed for all Infusoria, and therefore, of course, for the bell-animalcules), were essentially retained by Claparède and Lachmann, especially as regards the position of the mouth and anus, whilst at the same time they added the adoral ciliation, which was not indicated by Ehrenberg as a special character, and which they represented, from Lachmann's observations, as running round the ciliary disk in a spiral line and sinking into the buccal orifice.

In order to trace the fate of the Vorticellan family to its present constitution, it only remains for us to mention briefly the alterations which Stein, in his most recent work on Infusoria, has finally made in the system gradually elaborated by

* Die Infusionsthier auf ihre Entwicklungsg. untersucht, p. 85.

† Müller's Archiv, 1856, p. 348, note 1.

‡ Etudes &c. i. p. 117.

himself and by Claparède and Lachmann. The limits which he and his successors had at first widened have been again contracted by Stein himself nearly within the original bounds, as he has again separated the *Ophrydina* from the *Vorticellæ**, and accepted their right, first recognized by Ehrenberg, to form a carapaced family side by side with the naked bell-animalcules. He has also dissolved the union of the genus *Opercularia* with *Epistylis* made by Claparède and Lachmann, and raised the former, as was done by Ehrenberg, to the rank of an independent genus. On the other hand, he has separated *Urocentrum*, like Claparède and Lachmann, but on the grounds of a more accurate investigation than they had made—and also *Trichodina*, which had hitherto remained combined with the *Vorticellæ*, but differs from them in many essential points, especially by the possession of a peculiar adherent apparatus at the hinder end of the body, by the constant absence of a posterior circle of cilia and of a protrusible and retractile rotatory organ, &c., so that at first Stein even ascribes to the *Trichodinæ* the rank of a distinct family on account of these peculiarities†, although subsequently he arranges them as a genus of the newly formed family of the Urceolarina. As new members, the genera *Scyphidia* and *Gerda*, already introduced by Claparède and Lachmann, are accepted, and to these the genus *Astylozoon*, discovered by Engelmann‡, is added: it is characterized by the possession of two springing-bristles, situated at the posterior end, in place of a stem.

Thus it comes to pass that, after all these changes, the present systematic constitution of our family (with the above-mentioned natural exception of the Stentors) is once more nearly the same as when it was founded by Ehrenberg. The genera, also, have again been brought back to their original number, namely eight; and these, after the alterations above indicated, are:—*Vorticella*, *Carchesium*, *Epistylis*, *Zoothamnium*, *Opercularia*, *Scyphidia*, *Gerda*, and *Astylozoon*.

The characters of the family thus united, as they have been developed or, rather, have gradually acquired a sharper prominence in the way above described, may now be summed up in the following points:—In the first rank we must place the position of the mouth and anus in a common cavity in the bottom of the first section of the nutritive tube, the so-called vestibule, which was correctly recognized and indicated as a primary character by Ehrenberg. Next to this comes the

* Der Organismus der Infusionsthiere, ii. p. 168.

† Der Organismus der Inf. ii. p. 146.

‡ Zeitschr. für wiss. Zool. xi. p. 389, pl. 31. figs. 15, 16.

peculiar nature of the anterior rotatory organ, or the so-called adoral ciliary zone, which, in the true *Vorticellæ*, according to Claparède and Lachmann, always forms a *left-handed spiral*, running round the ciliary disk and then sinking into the vestibule, which commences between the peristome and the ciliary disk. The *ciliary disk*, i. e. the whole rotatory organ, can moreover be *retracted* into the interior of the body, and in this case is closed up by the membranous peristome as by a *sphincter* or a *screen*. When the *ciliary disk* is opened outwards, it is surrounded, as if by a collar, by the *peristome*, which is separated from it by a more or less deep furrow, and *rolled outwards*. The faculty of suddenly *springing back* of the whole body, which contracts at the same time, and of the stems, where contractile stems are present, is connected as an essential character with the retractile rotatory organ.

For the closer limitation of the Vorticellina, with regard to the allied families, especially the Ophrydina, the gelatinous envelope, which occurs in the latter and is wanting in the *Vorticellæ*, has been again adopted by Stein as the distinctive character between the two families, it having been already, as we have seen, employed by Ehrenberg for this purpose, but suppressed by Claparède and Lachmann. For my own part I can only regret this repeated separation, as, if we leave out of consideration the stem of the Vorticellina and the envelope of the Ophrydina, the two families agree so closely in their whole habit, structure, and vital phenomena, even to the most minute points, that, in the presence of this agreement, a severance of the Ophrydina from the immediate alliance of the *Vorticellæ* must be regarded as forced, and opposed to the natural relationship of these two groups. Probably even the most experienced and careful observer would scarcely be able to recognize, as such, a fissional scion of an Ophrydine (e. g. *Cothurnia*, see Pl. XII.) furnished with its posterior circlet of cilia, and just escaped from the envelope of its parent—that is to say, to distinguish it from the fissional scion of a true *Vorticella*. It is therefore merely the exterior finger-like envelope that is destined to separate the two families. But this alone, as we shall endeavour to show, can not suffice for the satisfactory establishment of this separation. If we could put opposite to each other the forms furnished with an envelope and adherent by short peduncles, and at the same time perfectly freely movable and non-pedunculate forms, such as may be represented by the fissional scions or by *Gerda*, the separation under consideration would perhaps appear more justified. But most *Vorticellæ* are likewise attached to peduncles, which on their part, again, are attached—with the exception of two

forms, namely :—the *Astylozoon* described by Engelmann, which rejoices in constant spontaneous mobility, but at the same time possesses two springing-setæ (*Schnellborsten*) at the hinder end of the body, perhaps as the homologue of the peduncle; and, further, the genera *Scyphidia* and *Gerda*, which are, indeed, completely non-pedunculate, but are more or less sessile. But if we examine the peduncle of the *Vorticellæ*, especially in comparison with the peduncle and envelope of the Ophrydina, we cannot reject out of hand the intimate correlation of these structures. The peduncle of the *Vorticellæ* consists of a hyaline homogeneous exterior envelope or sheath and a darker, more or less granular axis. The latter is either muscular substance*, and in this case, with the whole peduncle, retractile (*Vorticella*, *Carchesium*, &c.), or the axis contains no muscular elements, and then the peduncle is rigid (*Epistylis*). But in both cases the exterior hyaline envelope of the peduncle embraces the hinder basis of the body of the animal, whilst the axis alone penetrates into this base, becoming amalgamated with it, and here either serves merely for the attachment of the animal and of the retractor muscular elements in it (*Epistylis*), or, when the axis itself is of a muscular nature, radiates out continuously in the body (*Vorticella*, *Carchesium*). Now in the Ophrydina in general both the envelope and the body of the animal are likewise attached by a peduncle, although this is usually very short; and yet this may be regarded as morphologically equivalent to the peduncle of the *Vorticellæ*, and, indeed, especially to that of *Epistylis*. The sheath which in the *Vorticellæ* envelopes the axis of the peduncle, and terminates at the hindmost base of the body of the animal, is continued forward beyond this base in the Ophrydina, rising into a wide beaker-shaped case, within which the whole animal can retract itself. But even the axis of the Vorticellan peduncle is not wanting in the Ophrydina, but it is what, just as in the *Vorticellæ*, enters the base of the body and effects the attachment. Thus the more accurate investigation of the constitution and secretion or development of these structures may only render their identity still more clear. From all this it seems to me more natural to accept the individual genera of the Ophrydina as members of the Vorticellan family than to separate them from the latter.

Stein has further placed the family of the Vorticellina

* We retain here the denomination "axis" for the sake of uniformity, even for the contractile peduncles, although, as is well known, in *Vorticella* and *Carchesium* the muscular cord has a spiral course round the axis within the sheath, and only occupies a position in accordance with the true axis in *Zoothamnium*.

under his order of Peritrichous Infusoria*, in which it forms the true ordinal type, the "nucleus and central point" to which the other groups approximate upwards and downwards.

We have treated the systematic history of the Vorticellan family in more detail perhaps than the following observations may render necessary; but the history of the classification of a group of animals is always the true expression of the development of the knowledge of it; and in the present case it is of the greater interest, because it shows in how rare a fashion the Vorticellina have shown themselves to be a coherent and closed group, as, in spite of all efforts at further development, the systematic combination has remained essentially the same, although the characters in the meanwhile, as we have seen, have attained a much greater sharpness. But, besides this, we shall be able often to make use of the stand-point arrived at in the above explanations in our further statements, in order to attach our own observations, without being constantly obliged to make long digressions.

[To be continued.]

XIII.—*On the Microxylobius Westwoodii, Chevr., from St. Helena.* By T. VERNON WOLLASTON, M.A., F.L.S.

HAVING lately had an opportunity, through the kindness of W. W. Saunders, Esq., of examining the type of the little Curculionideous *Microxylobius Westwoodii*, from St. Helena, which was described in the first volume of the Entomological Society's Transactions, and which, after the lapse of thirty-six years, still remains unique in his collection, I have thought that it would be worth while to draw out an accurate diagnosis of it, in order to call attention to the exact characters in which it recedes from the other members of the genus (twelve in number) which have hitherto been brought to light. And this seems to be the more desirable, since the few words of M. Chevrolat which take the place of a description are quite insufficient for even its approximate identification. Judging solely from the excellent figure of it which was supplied by Prof. Westwood, I had imagined that it might perhaps prove to be identical with the species which I enunciated, in 1869, under the name of *vestitus*; but I now perceive that it is not only totally distinct from that insect, but equally so (as may be gathered from the subjoined remarks) from every other *Microxylobius* which has come under my notice.

* Der Organismus der Infusionsthier, ii. p. 168.